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Comments on Chemicals and Wild Life

LIKE THE FLOWERS that bloom in the spring, reports and articles dealing with the danger of agricultural chemicals to man and wild life, have blossomed forth with their usual unfailing regularity. However this year, we are pleased to note, there is a slight change in the approach of the wild life organisations for instead of yelling blue murder they have *attempted* to gather and present evidence in a logical manner. It is also evident that they recognise the necessity for the use of chemicals in agriculture. The organisations are to be commended for trying to present us with further information on the relationship between the use of chemicals and wild life, unfortunately they have failed to supply any information which was not already known.

There are many reasons for this failure to progress, noteable reasons being the lack of trained observers, which has resulted in some appalling lapses in the methods of investigation, and lack of funds. It is also apparent that there has been insufficient knowledge of agricultural chemicals and, perhaps surprisingly for naturalists, a failure to appreciate the importance of studies on ecology, behaviour and population dynamics.

As an example let us consider the recently issued *Report No. 1 of the BTO-RSPB Committee on Toxic Chemicals* which concludes:-

"In reviewing the evidence contained in this report it may be said that in six cases we have conclusive evidence that seed dressings killed birds. In other cases there is very strong circumstantial evidence which can leave little room for doubt that toxic agricultural chemicals, particularly in the form of seed dressings and less obviously in the form of sprays, have done immeasurable damage to game interests and wild life in this country in the first six months of 1960."

It is not disputed that seed dressings can kill birds, for these materials are designed to kill pests and we have not yet developed the requisite 'ideal pesticide'. Equally it will not be disputed here that there is circumstantial evidence that seed dressings have caused the death of birds even though some of the evidence which the above Committee considers reliable is in our opinion extraordinarily unreliable.

However we do not wish, in this instance, to discuss the validity of the evidence in the report for readers may wish to judge this for themselves; it is perhaps sufficient to say that in our opinion death in many cases was attributed to agricultural chemicals when no other cause was obvious despite the fact that little is known of avian diseases and that it is doubtful if the observers were scientifically trained let alone expert veterinary clinicians or toxicologists.

Our main criticism is with regard to the conclusion that agricultural chemicals have done "immeasurable damage to game interests and wild life". Even if the evidence quoted in the report could be considered faultless and a true representation of the effect of agricultural chemicals on wild life it would still offer no support to this bald statement because the committee have neglected to carry out the first, and basic essential of *any* investigation let alone a scientific one. In other words they failed to establish any sort of standard or control on which the evidence could be judged.

The report itself states that "It is unfortunate that in the vast majority of cases no actual count was made of birds killed", but not only have they failed to give an actual number or an estimate of the number of birds definitely or even supposedly killed by agricultural chemicals they have also failed to give an indication of the number meeting their death through natural causes. Nor was their any mention of the total population of any one of the species supposedly affected. Yet such information is essential if we are to find out whether or not there is any deviation from the normal population trend. As the report has not established that there has been any unusual deviation in the numbers of a species how can they state that agricultural chemicals are causing immeasurable damage? In fact the weakness of the statement is revealed when one considers the case of the pigeon. According to the Report the pigeon is the bird most seriously affected but the pigeon population appears to be increasing despite natural deaths, organised nest destruction and shooting by Rabbit Clearance Societies, indeed the pigeon is one of the major pests of British Agriculture.

The second most seriously affected bird, according to the report, is the pheasant, which can only doubtfully be considered as wildlife since the population is maintained at an un-naturally high level by man. Incidentally diverging for a moment one has only to examine the history of gamekeeping and natural history records to find that mans' attempt to maintain the high pheasant population has included the killing of some of our most beautiful birds of prey and the trapping of the lively, lithe and lissome members of the weasel family. However to get back to our main theme there has been no comparison by the B.T.O.—R.S.P.B. Committee, between the number of pheasants dying as a result of eating dressed seed and the numbers suffering from lead poisoning administered by those nature lovers who comfortably entrench themselves in a line while a horde of beaters drive the birds onto the waiting guns. In addition the natural death rate (at the moment there is a gape worm (*Syngamus spp.*) infection spreading through the pheasant population of the country) is, in the eyes of the naturalists, of no apparent significance compared with the deaths 'caused' by agricultural chemicals, since they do not appear to have compared them.

There also appears to have been no attempt to correlate the total population of any one species with the available food supply other than that unwillingly donated by farmers but this is important since some of the birds dying through eating dressed seed might, in any case, have died through starvation. One has only to examine the report of the Animal Health Trust (commonly referred to as Captain C. F. Crawshay's report), on seed dressings and wild life, to find that the birds in the experiment were extremely reluctant to eat dressed seed. Indeed in one test the treated grain was so repellant that, despite hunger, only 15oz. of grain was consumed by five birds in a test period of 30 days. Taking into account the normal consumption of food the starvation factor as a cause of death could not be ignored. Recent experience with aerial sowing also suggests that birds are reluctant to eat treated seed. There is therefore the possibility that some species of birds will only take treated grain when there is insufficient alternative food available.

Another point on which no comment was made was the extent to which these supposed incidents could have been avoided by correct usage. We are not told how many cases resulted from negligent disposal of surplus seed and empty chemical containers, inadequate covering—either because of negligence or the capriciousness of our climate—of sown seed or, in view of the number of cases where pigeons were involved, where there was a deliberate unlawful attempt at poisoning.

In drawing their conclusion the committee also appear to have committed the error of assuming that, by finding dead animals in one field that has either been sown with dressed seed or sprayed with some pesticide, it can be concluded that every field so treated is equally dangerous to wild life. This assumption is invalid if we are to follow the views of Sir William Slater, who, in a recent article said that " almost every combination of sun, rain and wind will produce a different set of risks, varying with the habits of the animals and birds feeding on it. There is an infinity of different circumstances due to seasonal variations and to the location of treated crops. Two fields only a few hundred yards apart may present entirely different risks; the same field treated in the same way in successive seasons may in the one cause no casualties, in the next provide reports of poisoned wild life".

Complex and variable as the situation is, it could be made even more nebulous by introducing such hypotheses as—"If we ceased to use agricultural chemicals more land would be required to maintain our necessary agricultural production, this would entail further encroachment into our nature reserves thus depleting the habitats and food supplies of our wild life, which in

Continued on page 165

BHC—A HIGHLY ACTIVE INSECTICIDE AGAINST TIMBER BORERS

By Dr. F. S. DOWNING*

This is the sixth article in the series on the chemical, physical and biocidal properties of the organic solvent type preservatives used in the treatment of timber.

WHEN benzene hexachloride (BHC) first became available for commercial development in 1945, trials at that time showed that it was highly toxic to the insect borers of timber. Unfortunately most of this early work was not published but it was followed by more critical observations the more important of which, both published and unpublished, will be reviewed in this paper. Particular attention will be paid to the timber borer problem in temperate climates.

Chemical and physical properties

Benzene hexachloride ($C_6H_6Cl_6$), commonly called BHC, contains four main isomers of which only the gamma isomer is strongly insecticidal. It is available as technical BHC which contains the gamma isomer plus the other isomers in varying proportions depending on the method of manufacture, and as lindane, a name coined in the U.S.A. and now in general use for the gamma isomer of not less than 99% purity.

Technical BHC is an off-white to brown solid with a musty odour. Lindane is a white crystalline solid with a very slight musty odour which is just detectable to some people and not to others.

The gamma isomer of BHC, usually called gamma-BHC, is stable to strong acids, light and heat but unstable to alkalis, particularly at a pH above 9.5. Gamma-BHC melts at 112°C. and begins to vaporize more rapidly at this temperature. The solubility of gamma-BHC in water is only 4p.p.m. but it is very soluble in a wide range of organic solvents. These are listed in Table 1.

Formulations

Formulations of technical BHC and lindane for timber borer control are available as ready-for-use oil sprays containing 0.5% - 1% gamma-BHC, as liquid concentrates containing 10% - 20% gamma-BHC for dilution with oil, as emulsions or emulsion concentrates containing 6.5% - 20% gamma-BHC for dilution with water, as dispersible powders containing up to 50% gamma-BHC, as smoke generators and as pressurised aerosols. These formulations may be based on either lindane or technical BHC.

Both lindane and technical BHC are compatible with most of the insecticides and fungicides used in timber preservation such as dieldrin, DDT, pentachlorophenol (PCP), chloronaphthalene (MCN), polychloronaphthalenes, metallic-naphthenates, and ortho-phenylphenol (OPP). Aqueous solutions of sodium pentachlorophenate and sodium ortho-phenylphenate are alkaline and therefore decompose BHC. Mixtures of gamma-BHC and sodium pentachlorophenate or sodium ortho-phenylphenate should therefore be made up and used immediately. Alternatively the addition of 2% borax to the mixture will reduce the pH of the sodium pentachlorophenate solution to a sufficiently low level to prevent quick decomposition of the BHC. Unfortunately borax fails to reduce the pH of sodium ortho-phenylphenate sufficiently to enable a BHC/sodium ortho-phenylphenate spray or dip to be kept for even a few days without breaking down the BHC.

Toxicology

Technical BHC and lindane are amongst the safest of insecticides used for timber borer control work. The toxicology of technical BHC can vary depending on the method of manufacture since technical BHC need not necessarily contain constant proportions of alpha, beta, gamma and delta isomers. Frequently formulations

* *Plant Protection Ltd.*

TABLE I.
Solubility of gamma-BHC in Common Solvents

Solvent	*Grammes per 100 grammes solvent at 20°C.*
Acetone	77
'Aromasol' H*	29
Cyclohexanone	72
Diesel oil	4
Methylene chloride	44
Solvent Naphtha (90/190)	15
Solvent Naphtha (90/160)	18
Kerosene (odourless distillate)	2
Paraffin	3
Trichloroethylene	15
White oil (Shell Risella 17)	2
White spirit	5
Xylene	33

* *obtainable from Plant Protection Limited.*

of technical BHC are fortified with lindane. As a guide the LD_{50} oral to rats of BHC isomers, as given in "The Official Compendium of the Association of American Pesticide Control Officials Inc." (1959), is as follows:-

alpha isomer — 500 mg./kg.
beta isomer — 6,000 mg./kg.
gamma isomer— 125 mg./kg.
delta isomer — 1,000 mg./kg.

In practice technical BHC commonly contains mainly beta and delta, as well as gamma, isomers so that the toxicity of the formulation can be judged in terms of the gamma isomer content.

No protective clothing is needed when applying BHC sprays except in confined spaces where a simple dust mask, and with some individuals goggles, is advisable. When using concentrates, particularly those containing solvents, care should be taken to wash off any splashes on the skin with soap and water. An example of the safety of BHC in practice is the wide spread use of this product in dispersible powder form as an 0.5% - 1% gamma-BHC house spray in tropical malaria control schemes. These schemes have now been in operation for fifteen years and operators wearing very little clothing have been drenched daily by fall-out of the spray when treating the interiors of the houses with no ill effect.

Taint

Lindane has been widely used during the past ten years in flour mills, grain warehouses, and tobacco stores, not only in space sprays but also as residual sprays applied to the warehouse walls and floors on to which bagged or packaged goods are subsequently placed. These sprays have even been applied directly to the packaged goods. Such widespread and continued use is evidence enough that lindane does not taint under these conditions. Placing goods on a treated timber surface, as may occur after an anti-woodworm treatment, is thus unlikely to cause taint from the insecticide although some oil diluents and organic solvents used in emulsible concentrates could cause taint if not allowed to evaporate before goods are placed on the treated surfaces.

Where technical BHC is used precautions must be taken since the musty odour is readily absorbed by food stuffs. This odour can persist on timber for weeks after application.

Effect on timber borers

The insect borers which attack timber from the time it is felled until it is finally used in buildings, furniture etc. can be divided into groups according to the stage of the timber, i.e.:—

Newly felled timber—Ambrosia beetles (pinhole borers), bark beetles and long horn beetles.

Newly sawn green timber—Powder post beetles (Lyctidae and Bostrychidae).

Timber in buildings—Powder post beetles, common furniture beetle, death watch beetle, house long horn beetle, subterranean and dry wood termites.

This list gives only the commonest insects and of these termites are found only in tropical and sub-tropical territories while the common furniture beetle prefers temperate climates.

Insecticides such as BHC, DDT, dieldrin, PCP and most others included in the organic solvent group of timber preservatives have been used very widely and successfully for many years by servicing companies both singly and in combination but very little work has been published on the efficiency of insecticides against the insect borers of timber found in temperate climates and still less on the persistance of these insecticides after application to timber. Ideally an assessment of an insecticide should include its activity against each insect species or at least each family. What information is available on persistence and efficiency will be reviewed in the next two sections and this information will then be discussed where applicable in the final section which summarises field recommendations for the control of all the major pests of timber.

Persistence

(*a*) *Application to timber*

Up to 1953 no work had been carried out on the persistence of BHC after application to timber but it had been assumed that the persistence of this insecticide would be much shorter than DDT due to the much higher vapour pressure of BHC compared with DDT. To clarify the situation Dr. H. H. S. Bovingdon began a series of experiments at the Jealott's Hill Research Station of Imperial Chemical Industries Limited. Various liquid formulations of lindane were applied to oak sapwood and the sapwood was subsequently infested at intervals with *Lyctus* powder post beetles. The oak boards were kept at room temperature in the laboratory.

TABLE 2.

Flight holes found in oak boards treated with gamma BHC and pentachlorophenol formulations in June 1953 and infested with Lyctus.

Totals from 3 replicates

Treatment	Year of infestation 1953		1954		1955		1956	
	Rate of application of insecticide gals./1000 sq. ft.							
	1	2	1	2	1	2	1	2
0.35 % gamma BHC/ kerosene solution	0	0	0	0	0	0	0	0
0.35% gamma BHC dispersible powder/water	0	3	0	2	2	0	0	2
0.35% gamma BHC emulsion	0	0	0	1	0	0	0	0
5% pentachlorophenol/ kerosene	0	0	8	6	6	0	0	0
Odourless kerosene	0	0	27	37	0	23	10	2
Water	125	36	126	67	3	52	5	8

TABLE 3.

Flight holes found in oak boards treated with gamma BHC smoke generators in June 1953 and infested with Lyctus in 1956

gamma BHC deposit (mg/ft)²	Total number of flight holes. Replicates 1	2	3	4
0	23	32	3	33
16	0	0	0	0
48	0	0	0	0

Freshly felled sapwood was used and each timber plaque was given a 10 second dip in the insecticidal liquid. Table 2 lists the formulations which were used and the results obtained. 5% pentachlorophenol was included in the test as a standard in view of its very widespread use as a timber preservative.

The results show that the 0.35% lindane spray gave complete protection for the three years duration of the experiment whether in kerosene solution or in emulsion form. The dispersible powder and the pentachlorophenol failed after one year.

A similar trial was carried out with smoke generators due to the increasing popularity of these devices at that time. The generators applied approximately 16mg. lindane per square foot to oak sapwood boards. These boards were kept at room temperature in the laboratory and infested with *Lyctus* powder post beetles at regular intervals. Table 3 giving the final year's results of these experiments shows that when the experiment was terminated after three years complete protection was still being obtained.

Unfortunately both the dip and smoke tests had to be concluded before attack took place since no more plaques were available. When planning the experiment it was believed that the BHC would have a short life on timber due to its relatively high vapour pressure. It was anticipated that the kerosene spray would have best persistence since organic solvents are generally expected to penetrate seasoned timber more readily than water. Nevertheless Bovingdon's experiments showed that the emulsion was as good as the kerosene spray and the dispersible powder almost as good.

The results with the emulsion could perhaps be explained if the insecticide had penetrated in the oil fraction of the emulsion. The dispersible powder and smoke generator trials are less easily understood. Both represent the application of crystalline BHC to timber with no solvent to carry the insecticide into the timber. Such applications on glass would remain insecticidal for a few days only so the BHC must be retained in some way by the timber

A similar phenomenon is found in the application of BHC to the walls of mud huts in standard anti-anophelene malaria control operations. Burnett[1] found that a BHC dispersible powder spray application to mud walls was still highly lethal to mosquitoes twelve months later. This persistence was thought to be due to physical adsorption of the insecticide on to the mud but no explanation for this phenomenon has ever been put forward.

Bovington's results with sprays have recently been supported by Miss J. Taylor[2] of the Forest Products Research Laboratory, who stated that a 10 second dip of green or seasoned timber in 0.5% gamma-BHC emulsion will give protection against *Lyctus* attack for up to three years.

Bovington's results with smokes should be interpreted cautiously when they are related to field applications of smoke generators in buildings. When a smoke generator has been ignited in a roof space the deposit obtained on inverted or vertical surfaces will be no more than a quarter of that on the floor. Bovington's trials utilized only the floor deposit so that the degree of protection afforded to all the timbers in a roof space by one smoke generator application will certainly be much less than might have been expected at first sight from his results.

In addition to the above Lyctus trials by I.C.I., tests against termites were also commenced in 1953 in conjunction with the Forest Research Department, Ibadan, Nigeria. Four replicates each of elm and spruce heartwood plaques were dipped for half a minute and thirty minutes in gamma-BHC/kerosene solutions and emulsions, then exposed above ground to termite attack from decoy strips maintained between the plaques and infested ground containing the termite *Macrotermes bellicosus* Smeithman. In addition plaques were similarly treated and exposed with a 5% pentachlorophenol/kerosene/diethyl carbonate solution as a standard in view of the wide use of pentachlorophenol as an anti-termite treatment for timber. The results are shown in tables 4 and 5. The reference to "slight nibbling" in

the results describes crazing of the surface only and is in fact complete protection if judged by the standards of C.S.I.R.O.[3], Canberra. C.S.I.R.O. rate timber as sound if it has "surface nibbles on any or all faces to a depth not exceeding $\frac{1}{8}$ inch". Thus in the Ibadan trials 1% gamma-BHC/kerosene solution was still giving protection after $4\frac{1}{2}$ years to all the spruce plaques after immersion in the spray for half a minute and to some of the elm plaques. Pentachlorophenol treatment broke down after $2\frac{1}{2}$-$3\frac{1}{2}$ years.

From the Ibadan, Jealott's Hill and Forest Products Research Laboratory results it can be concluded that gamma-BHC/kerosene solutions will give prolonged protection to both heartwood and sapwood, while gamma-BHC emulsion should be expected to give long persistence with sapwood only. The practical implications of these conclusions are discussed on pages 164 & 165.

It is of interest to compare the very variable degrees of uptake of insecticide by the heartwood in the Ibadan experiments, even though all the timber was taken from the same tree.

(b) Persistence of BHC in resins.

The mixing of insecticides with resins to increase their persistence has been tried with most insecticides and this type of application was first tried with BHC added to the resins of plywood by C.S.I.R.O., Canberra, in 1948. Plaques of plywood containing 0.16% gamma-BHC in the glue line (cold setting urea formaldehyde and casein glues) were exposed at regular intervals to *Lyctus* powder post beetle attack in the laboratory. After 12 years no attack has resulted. These results

TABLE 4.

Ibadan Termite Resistance Tests on Elm heartwood plaques (12″ x 6″ x $\frac{3}{8}$″). Exposed from June 1953 to date of inspection

Treatment	*Period of dip (mins)*	*Sept. 1954*	*Oct. 1955*	*Feb. 1957*	*Feb. 1958*	*Feb. 1958*
1% gamma-BHC in kerosene	$\frac{1}{2}$	O **2.8** 12	SN **4.8** 9	A **1.4** 10	A **0.9** 11	SN **2.8** 12
1% gamma-BHC in kerosene	30	O **3.0** 16	O **2.3** 13	SN **2.3** 14	SN **2.1** 15	O **3.0** 16
0.5% gamma-BHC in kerosene	$\frac{1}{2}$	SN 0.4 28	A **0.6** 25	A **0.2** 26	A **0.6** 27	A **0.4** 28
0.5% gamma-BHC in kerosene	30	SN **2.6** 32	A **0.3** 29	A **3.9** 30	A **2.6** 31	A **2.6** 32
5% PCP in kerosene + 10% diethylcarbonate	$\frac{1}{2}$	SN **14.5** 44	A **16.4** 41	A **24.7** 42	A **10.5** 43	A **14.5** 44
5% PCP in kerosene + 10% diethylcarbonate	30	A **17.5** 48	A **23.6** 45	SN **34.5** 46	A **27.0** 47	A **17.5** 48
Kerosene	30	A 56	A 53	54	55	56
1% gamma-BHC Emulsion	$\frac{1}{2}$	O **1.3** 68	A **1.0** 65	A **1.0** 66	A **2.8** 67	**1.3** 68
1% gamma-BHC Emulsion	30	O **5.6** 72	A **5.2** 69	A **6.0** 70	A **7.3** 71	A **5.6** 72
0.5% gamma-BHC Emulsion	$\frac{1}{2}$	A **1.1** 84	A **1.1** 81	A **1.2** 82	**1.0** 83	**1.1** 84
0.5% gamma-BHC Emulsion	30	SN **3.0** 88	A **1.1** 85	A **1.2** 86	A **1.5** 87	A **3.0** 88
Emulsion Solvents without BHC	30	A 96	A 93	A 94	95	96
Untreated		A 104	A 101	A 102	103	104
Kerosene and diethylcarbonate	30	A 108			107	108

TABLE 5.

Ibadan Termite Resistance Tests on Spruce heartwood plaques (12″ x 6″ x $\frac{3}{8}$″). Exposed from June 1953 to date of inspection

Treatment	*Period of dip (mins)*	*Sept. 1954*	*Oct. 1955*	*Feb. 1957*	*Feb. 1958*	*Feb. 1958*
1% gamma-BHC in kerosene	$\frac{1}{2}$	O **2.3** 4	SN **2.8** 1	SN **3.2** 2	SN **1.9** 3	SN **2.3** 4
1% gamma-BHC in kerosene	30	O **2.0** 8	O **1.2** 5	SN **2.8** 6	SN **1.8** 7	SN **2.0** 8
0.5% gamma-BHC in kerosene	$\frac{1}{2}$	O **0.5** 20	O **1.1** 17	O **1.2** 18	A **0.4** 19	A **0.5** 20
0.5% gamma-BHC in kerosene	30	A **0.8** 24	O **0.7** 21	SN **0.8** 22	A **2.2** 23	A **0.8** 24
5% PCP in kerosene + 10% diethylcarbonate	$\frac{1}{2}$	O **1.8** 36	O **7.7** 33	A **13.0** 34	A **10.0** 35	A **1.8** 36
5% PCP in kerosene + 10% diethylcarbonate	30	O **15.0** 40	SN **11.5** 37	A **4.1** 38	A **12.8** 39	A **15.0** 40
Kerosene	30	A 52	A 49	A 50	A 51	52
1% gamma-BHC Emulsion	$\frac{1}{2}$	O **1.5** 60	A **4.4** 57	O **3.5** 58	A **1.2** 59	A **1.5** 60
1% gamma-BHC Emulsion	30	O **5.8** 64	O **4.2** 61	O **2.6** 62	SN **4.1** 63	SN **5.8** 64
0.5% gamma-BHC Emulsion	$\frac{1}{2}$	O **1.3** 76	A **1.7** 73	A **0.6** 74	**1.6** 75	A **1.3** 76
0.5% gamma-BHC Emulsion	30	O **1.1** 80	SN **0.9** 77	A **2.0** 78	SN **3.0** 79	A **1.1** 80
Emulsion Solvents without BHC	30	O 92	A 89	A 90	91	92
Untreated		A 100	A 97	A 98	99	A 100
Kerosene and diethylcarbonate	30		A 105	A 106		

Key (*to tables 4 and 5*) Degree of Attack: *O = No attack*
SN = Slight nibbling
A = Attacked

Uptake of Insecticide (lb./100 cu. ft.): *Bold figures*
Sample Numbers: *Other figures*

Plaques assessed in 1954 were re-exposed to termite attack until February, 1958 and are recorded in the second column under Feb. 1958

Where degree of attack is not stated the plaque has either been lost or totally destroyed.

are of considerable practical significance where panelling or plywood packing cases need to be protected for long periods.

The application of these findings of C.S.I.R.O. has been limited by the general belief that only cold setting glues could be used with BHC. BHC is known to be more volatile than many of the chlorinated insecticides and it has, therefore, never been incorporated into plywood containing hot setting glues. Nevertheless, this application would be quite practicable since the highest temperature used with hot setting glues is 330°F. (166°C) and the average temperature is 245°F. (118C°). At this temperature only a very minor fraction of the BHC would be lost during the average setting time of six minutes for a ½ inch thick plywood, or 13 minutes for 1 inch thick plywood.

The use of BHC with highly alkaline glues has also been discouraged since it was believed that the insecticide would be broken down by the alkalinity. Nevertheless C.S.I.R.O. in field trials begun in 1950 included hydrated lime in the glue line of their plywood so that the pH was 10.9–11.3. Despite this high pH plywood containing only 0.11 lb. gamma-BHC per thousand square feet showed no sign of infestation when regularly exposed to *Lyctus* powder post beetle until 1957 when shallow pinholes were made. Two years later the plywood became heavily attacked where it was alongside heavily infested, untreated plywood. The reason for the failure of the alkaline glue to break down the BHC more quickly could only be due to the lack of water in the glue, which would otherwise have accelerated the process.

The casein glue used in the very successful 1948 C.S.I.R.O. trials reported above also had a pH of 11. There seems to be no reason therefore why BHC should not be used with highly alkaline glues, including casein, and alkali hardened phenol-formaldehyde glues also having a pH of 11.

Resin bonded chipboard or particle board has also been the subject of trials with BHC. I.C.I. Ltd. co-operated with the Forest Research Institute, Dehra Dun, who exposed plaques of resin bonded wood waste board containing 0.1% gamma-BHC in the glue to subterranean termite attack only. Surface nibbling was noticed almost immediately but deep penetration occured only after two years exposure. This quick failure of the test was almost certainly due to the ability of the termites to penetrate the very thin film of glue over those parts of the board where the wood chips were very near the surface. Undoubtedly the incorporation of insecticide into the wood waste as well as into the glue itself would be essential to achieve good protection.

Efficiency

Unfortunately no work has ever been published in which all the more important timber borers were compared in standard conditions against one insecticide. All comparative work has been between a range of insecticides using one or two insects as standard.

The Forest Products Research Laboratory, Princes Risborough,[4] working with *Lyctus* powder post beetles showed that 0.5% gamma-BHC emulsion or kerosene spray prevented the beetles from infesting English oak boards. Dr. Bovingdon (page 161, col. 1) obtained similar results with 0.35% gamma-BHC emulsion and kerosene solution.

The Forest Products Research Laboratory[5] working with plywood already infested with common furniture beetle found that 0.5% gamma-BHC/white spirit gave 100% control in the first year after treatment, but in the second year 2 beetles emerged, compared with 45 from the untreated control. White spirit alone gave the same result in the first year, but in the second year 14 beetles emerged from the treated board and 47 from the untreated control.

Dr. Bovingdon carried out similar work at Jealott's Hill Research Laboratory with *Lyctus* infested timber in 1952. After spraying the infested timber to run-off with 0.35% gamma-BHC/kerosene solution, exit holes appeared during the first year after spraying but many of them were smaller than normal and beetles were found dead within the holes. In the following year only small holes with dead beetles were found and no full-sized exit holes.

Dr. G. Becker[6] compared the susceptibility of the common furniture beetle and the house longhorn beetle to various insecticides. Blocks of pine sapwood were treated with graduated dilutions of preservatives by vacuum and the retention was determined. After storage of the blocks for 4 weeks ten egg-larvae of the house longhorn beetle or middle sized larvae of the common furniture beetle were each transferred to the wood blocks and these were stored at 20°C. and 70% relative humidity. After a further 4 and 12 weeks the blocks were split and the larvae examined. The toxicity limits were defined between a lethal concentration that kills all larvae and the next lower concentration leaving some of them alive. The results are shown in table 6.

These show a very marked susceptibility to BHC by the common furniture beetle compared with the

TABLE 6.

Insecticide	*Toxicity values in g./m³ wood for* Hylotrupes *larvae test period*		Anobium larvae *test period*	
	4 wks.	*12 wks.*	*4 wks.*	*12 wks.*
gamma-BHC	2	< 0.03	70	70
aldrin	0.5	0.2	4,000	500
dieldrin	0.5	0.1	10,000	1,500
Chlordan I	0.5	0.1	7,000	1,000
Chlordan II	6	3	20,000	< 2,000
Toxaphene	6	4	> 20,000	4,000
DDT	15	1.5	> 20,000	4,000
parathion (E. 605)	16	12	8	4

other insecticides, except parathion (E605) which however cannot be used in houses due to its high mammalian toxicity. House longhorn egg larvae are much more susceptible to BHC and most of the insecticides tested than the middle sized larvae of the common furniture beetle.

Repellency is also exhibited to wood boring insects by some insecticides. Forest Products Research Laboratory, Princes Risborough,[5] report that 20mg. gamma-BHC per square foot prevents egg laying by the common furniture beetle and BHC prevented egg laying by the death watch beetle. Normal field applications of 0.5% gamma-BHC spray at 1 gallon per 200 square feet usually applied twice in the treatment of building structures deposits 220mg. gamma-BHC per square foot—a good reservoir of repellent to protect against subsequent attack.

Recommendations for the field use of BHC

(*a*) *Ambrosia beetles* (*pinhole borers*)

No laboratory work has been published on the relative effectiveness of insecticides to the ambrosia beetles infesting hard woods but field tests by the West African Timber Borer Research Unit[7] led to the following conclusions being made:– "After testing gamma-BHC, aldrin, dieldrin, endrin, DDT, and creosote, W.A.T.B.R.U. recommend 0.75% gamma-BHC emulsion or oil spray for the protection of logs".

In practice BHC emulsion is used in regions of low rainfall while the oil spray is used where logs are subjected to heavy rainfall or where they are stored in lagoons or transported as rafts down river. In some regions dispersible powder sprays are being used successfully instead of the more expensive emulsions.

(*b*) *Bark beetles*

Bark beetles cause serious damage to newly felled conifer logs, and in some instances introduce spores of sapstain fungi so reducing the value of the timber for paper pulp or lumber.

The commonest bark beetles in Europe are *Myelophilus piniperda* L. the pine shoot beetles, *Ips typographus* L. and *Pityogenes chalcographus* L.–beetles attacking pine and spruce. In North America *Dendroctonus* is one of the best known pests. R. C. Fisher, G. H. Thompson, and W. E. Webb in their review of ambrosia beetle control[8] state that tests by the United States Bureau of Entomology and Plant Quarantine included BHC, DDT, methoxychlor, toxaphene, and other recently developed insecticides but BHC was consistently pre-eminent as a preventative on hard wood and pine logs. D. Boocock[9] described experiments in which BHC was shown to be superior to DDT for eradicating an infestation of *Myelophilus piniperda* in pit props in the United Kingdom. He states that this result was in line with other evidence in North America in which BHC was shown to to be superior to other insecticides such as DDT, chlordane dieldrin, toxaphene, and creosote, both for preventing logs from being attacked and for the destruction of the beetles beneath the bark of logs already infested. The dosage recommended is 0.4%-1% gamma-BHC emulsion at 1 gallon per 100 square feet to drench the bark. Emulsions are highly effective in dry conditions but oil is preferable during heavy rainfall. At least two months protection can be expected.

(*c*) *Powder post beetles*

The laboratory evidence outlined earlier from the Forest Products Research Laboratory and Jealott's Hill has resulted in the widespread use in the field of 0.5% gamma-BHC emulsions, dispersible powder and kerosene sprays, applied both as sprays and dips to sawn timber for protection during seasoning, transport and storage, and for treating furniture and other timber containing sapwood infested by powder post beetles. The West African Timber Borer Research Unit has also published in their Technical Bulletin No. 1, 1959, that the only insecticide recommended for the protection of sapwood against powder post beetles is 0.5% gamma-BHC spray.

(*d*) *Common furniture beetle*

Dr. Becker's results (Table 6) supported the widespread acceptance by servicing companies from their practical experience of gamma-BHC for common furniture beetle control. The F.P.R.L. results (page 163) warn that complete control must not be expected with one treatment if by control it is meant that no new exit holes will appear after spray treatments. The extent to which such treated timber can be re-infested, however, has never been tested experimentally but such re-infestation would be unlikely for some years since the beetle would be repelled from laying eggs on the treated timber (see F.P.R.L. results in col. 1). The exact period during which beetles would be repelled is not known but as common furniture beetle infests sapwood primarily, and sapwood has been shown to retain its BHC for at least three years (page 161) then protection against re-infestation from common furniture beetle can be expected for at least this period.

(*e*) *House longhorn beetle*

This beetle is a widespread pest on the Continent of Europe and is now well established locally in the United Kingdom. It attacks the sapwood of soft woods only. The heartwood of softwoods is much less susceptible and hardwoods are immune. Becker's results (Table 6) show that gamma-BHC is as effective as other chlorinated hydrocarbon insecticides against house longhorn beetle. In practice a 1% gamma-BHC/oil spray is applied to infested timber after all areas containing borings have been cut away. Fortunately only sapwood need be treated and this is usually very permeable to spray so that good control is achieved.

(f) *Death watch beetle*

No experimental work on the control of this beetle with gamma-BHC has been published. Nevertheless gamma-BHC is widely used for this purpose by servicing companies. The major difficulty is to ensure that the insecticide reaches the infestation which is frequently most serious in the centre of beams. Surface treatments are usually not enough and should be supplemented by injection through flight holes or through holes specially drilled for the purpose. Where BHC has been introduced into the centre of beams its loss by evaporation will be very slow and persistence for many years can be expected. This protection will be aided by the repellent effect of BHC on death watch beetles (page 164).

General wood preservation

The long persistence demonstrated in this paper for gamma-BHC applied by surface treatment to sapwood and heartwood makes BHC very suitable for incorporation in a general timber preservative for the protection of structural timbers, fence posts etc., in temperate and tropical climates. Such a preservative is best based on oil so that a fungicide such as orthophenyl phenol or pentachlorophenol can be incorporated.

ACKNOWLEDGMENTS

I should like to acknowledge the help of my colleague Dr. H. H. S. Bovingdon, who carried out most of the research work described in this paper at Jealott's Hill.

In addition my thanks are due to the British Wood Preserving Association, The Timber Development Association, the Forest Products Research Laboratory, and to Mr. D. Boocock of Preservation Developments Limited for helpful discussions during the preparation of this paper.

REFERENCES

1. BURNETT, G. F. (1957). *Bull. Ent. Res.* **48**, p. 631.
2. TAYLOR, J. M. (1960). *Timber Technology* **68** pp. 262-263.
3. ANON (1957). *C.S.I.R.O. Bulletin No.* 280 p. 18.
4. ANON (1956). *F.P.R.L. Annual Report* p. 37.
5. ANON (1958). *F.P.R.L. Annual Report* p. 38.
6. BECKER, G. (1953). *Holz.Roh.u. Werkstoff* **11** p. 45-50 and 1958 *Rep. British Wood Preserving Assoc.* p. 130.
7. ANON (1958) *West African Timber Borer Research Unit Progrss Rep.* for 1955-1958, p. 31.
8. FISHER, R. C., THOMPSON, G. H. and WEBB, W. E., (1954) *Forestry Abstracts* **15**, p. 3.
9. BOOCOCK, D. (1959) *Timber Technology* **67**, p. 368.

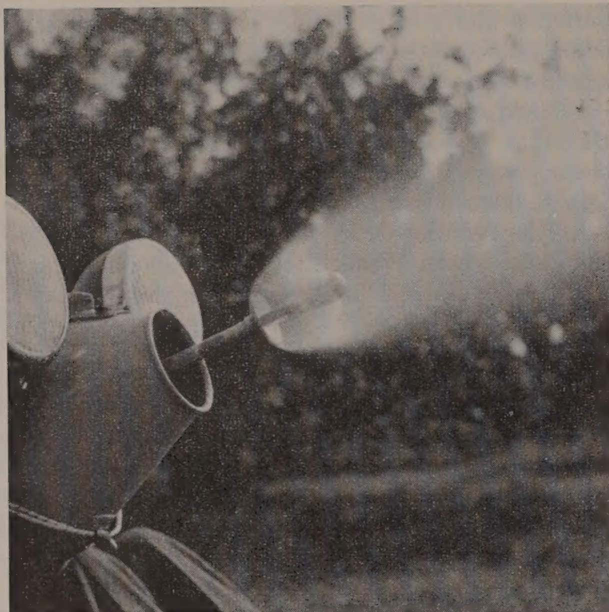
Chemicals and wild life (*Continued from p. 158*)

turn would be depleted by the natural struggle for survival. Could it not therefore be argued that the use of agricultural chemicals, by allowing us to maintain our nature reserves, enables us to maintain a greater abundance and wider variety of wildlife?"

These few brief criticisms of just one report will, we hope, serve to show that the question of the unwanted effects of agricultural chemicals on wild life is so vast and complex that no one organisation can handle it. It is perhaps unfortunate that we singled out the BTO-RSPB report on which to base our criticism for the occasional phrase in the report suggests that they may have realised this. But if they did how could they, in view of the number and importance of the questions they left unanswered, justifiably conclude that immeasurable and irreparable damage had been done to wild life, or imperiously state that immediate steps should be taken to reduce the hazards without mentioning that chemical manufacturers and the M.A.F.F. have been taking such steps since the time that the first synthetic pesticides were introduced and that they are constantly searching for newer and safer chemicals?

It is not suggested that the committee should have carried out the above surveys, for anyone who has experienced the difficulties of estimating animal numbers or of experimenting in the subject of population dynamics will realise the laborious and time consuming nature of the task, but the important bearing of such studies on the question of the effects of agricultural chemicals on wildlife should have been mentioned.

To sum up, it can be stated that the use of some agricultural chemicals presents an inherent hazard to wild life. The extent of the risk has not yet been established with any reliable accuracy though it may be serious locally. On the one hand the seriousness of the risk is in danger of being greatly exaggerated because emotions are involved; on the other hand the danger may be played down because of the lack of acceptable evidence. The blind following of either of these lines could in the first case threaten agriculture and in the second threaten our wildlife. The situation must therefore be put into proper perspective by detailed analytical surveys and experiments Such investigations will require a great deal of effort and money and those concerned must merge their various talents into a co-ordinated approach to the problem. (eg. as at the discussion on Seed dressings and Wildlife held on 21st December 1960 and attended by the Nature Conservancy, Council for Nature, Country Landowners Assoc., N.F.U., N.A.C.A.M., A.B.M.A.C., M.A.F.F. and the D.S.I.R. (Dept. of Gov. Chemist). Unfortunately, it will also take time to gather in and analyse all the necessary details but however irksome this may be the parties concerned should, in the meanwhile, refrain from making one sided statements. Users of agricultural chemicals should follow label instructions to the letter and where no indication of the chemical's toxicity to wild life is given, it would be best to assume a potential hazard and take all possible precautions.



The parasol nozzle of the Whirlwind Professor. Photo Universal Crop Protection Ltd.

DEVELOPMENT OF CONCENTRATE SPRAYING — PART III. CROP SPRAYING

By G. J. ROSE* B.Sc., F.R.E.S.

In the first two parts of this article the author discussed the early history and the development of thermal fogs and mechanical aerosol generators.

THE DECADE and a half that followed the cease fire in 1945 provided the greatest stimulus for the development of the concentrate idea.

The discovery of the insecticidal properties of the chlorinated hydrocarbons and the herbicidal properties of certain plant hormones when applied in small doses of active material per acre promoted the search for methods to eliminate the need for large volumes of inert diluent liquids.

Each attribution in the pre-war epoch is difficult due to the relative infrequency of inventions and the distorting effects of time. Attribution in the post war period is, if anything, rendered more difficult due to the large number of independent developments that have taken place in both Europe and the United States.

An attempt has been made here to establish the correct sequence in time of the developments which appear to have been of fundamental importance in advancing our techniques of concentrate spraying. It would be unwise to suggest that because a time sequence can, with difficulty, be traced there has been any logical evolution of ideas. This may be due to the fact that there is little agreement amongst plant protection workers upon desiderata.

One wonders whether it is the number of variables confronting the agricultural experimentalist coupled with the rural nature of much of their work that has proved attractive to men of great individuality. Personalities employing the intuitive method certainly appear to play a more dominant role than they do in other industries.

This may account for the strong proofing against the influence of contemporary developments in other countries which seems to be a feature of so many senior workers in plant pathology and agricultural engineering. Such a condition would tend to lead to random achievements rather than logical developments.

AIR BLASTS AND BOOM SPRAYERS

Perch[22] in 1944 produced in the United kingdom his first high volume air assisted sprayer. This machine, became very widely known as the 'Autoblast' and it caused a revolution in British orchard spraying practice. It was primarily designed to apply higher volumes per acre of spray than was easily possible with an hydraulic system which had as a controlling factor the output of a high pressure pump combining high output with a low power requirement. A large volume of fairly high speed air was used to provide secondary atomisation and principally to carry the resultant droplets into the canopy.

Later modifications of the 'Autoblast' led to a good deal of the early experimental work in reduced volume spraying.

* *Editor, Agricultural & Veterinary Chemicals.*

1945[23], also witnessed the birth of a piece of equipment which was to play as significant a role in U.S. horticulture as was the Autoblast in Britain. In that year the Buffalo Turbine Agricultural Equipment Company released its first commercial airblast sprayer. Both the John Bean Company and the Lawrence Aero-mist Company began marketing air blast machines shortly afterwards. All these machines consisted in essence of an air system into which spray from hydraulic nozzles was fed. They were all high volume machines but implicit in their design was the possibility of modification that would enable lower volume/higher concentration experiments to be carried out later.

1946—The first break through

Although high volume airblast machines had been produced before 1946 the honour of the first break through towards concentrate spraying in orchards must go to James Marshall[24] of the Dominion Entomological Laboratory at Summerlands, British Columbia. Marshall's early experiments, with a portable machine which employed an airblast to act as a secondary atomising agent and carrier for droplets produced from simple hydraulic nozzles, were carried out at reduced volumes against codling moth, pear psylla and European apple scab.

Although the first machine used by Marshall was not entirely satisfactory it led to the later production of the Okanagan experimental sprayer by the joint efforts of the British Columbia and Canada Departments of Agriculture and the Defence Research Workshops.

The Okanagan experimental sprayer produced a very large volume of high pressure air and great attention was paid to the atomising characteristics and disposition of the low volume hydraulic nozzles.

In British Columbia Marshall was concerned with large standard fruit trees. The Okanagan sprayer enabled him to reduce the volume of spray applied per acre from 400 plus gallons to between 50-100 gallons whilst maintaining adequate protection. Labour cost economies of the order of 75% and chemical economies of approximately 20% were realised by the adoption of the Okanagan machine in British Columbia.

Fan jets and the start of low volume boom spraying

Boom sprayers for the application of chemicals to control pests, weeds and diseases of ground crops had come into use during the twenties. They were generally trailer type machines designed for high volume work equipped with piston type pumps and hydraulic nozzles. The source of power for these machines was derived either from land wheels or from an independent engine. Essentially they were modifications of high volume hose and hand lance orchard sprayers.

The advent of such materials as DDT, the hormone weedkillers and fine fungicidal suspensions of the fixed copper type stimulated the development of low volume boom sprayers.

Since improved atomisation appeared to be the logical key to reduction in spray volume, nozzle design for boom sprayers was subject to reappraisal.

In the U.S.A. circa 1946 it was discovered that fairly satisfactory atomisation could be obtained if fan jets, of the type fitted to air humidifiers were incorporated into a boom system. The fan jets embodied the great advantage that only relatively low liquid pressures were required to provide satisfactory atomisation. This low pressure requirement meant that smaller low pressure pumps of the gear or centrifugal type could be employed, Such pumps demand much less power than high delivery piston pumps and they could use as a source of power the p.t.o. of a tractor.

In Britain Dr. W. G. Templeman[25] of Imperial Chemical Industries carried out a lot of the initial experimental work. Imported American nozzles were used in the earliest trial but during the search for a suitable British equivalent Mr. B. J. Evans (Marston Excelsior Ltd.) suggested that Bray gas jets (made by G. Bray & Co. Ltd., Leeds) should be tested as spray nozzles. At about the same time it was learned from Mr. R. P. Fraser and Mr. M. O. Coulter (Imperial College of Science) that Bray jets were very useful for the application of insecticides. These jets have a ceramic tip, with a moulded orifice, mounted in a brass threaded holder. Allman & Co. of Chichester were probably the first firm to manufacture hydraulic low volume boom sprayers commercially in Britain.

The Agro Sprayer

Fan jets with their fine apertures are not really suitable for the application of suspensions. In 1946[26] Plant Protection Ltd. and Imperial Chemical Industries Ltd. developed what they called their Agro Sprayer. This was the first boom sprayer which incorporated pneumatic rather than hydraulic nozzles. Each nozzle consisted of a venturi into the constriction of which passed a simple liquid feed tube of fairly large aperture. Liquid issuing from the feed tube was atomised by air as it expanded and accelerated beyond the venturi constriction. The Agro sprayer which was manufactured commercially by Ransomes, Sims and Jeffries of Ipswich, consisted of a fan whose output was channelled through an air ducting which formed the boom. Venturi nozzles were placed at intervals along the boom to which liquid was fed from a low pressure pump.

The parasol nozzle

In 1949 there were three developments, two Dutch and one British, which have played a very significant role in the move towards concentrate spraying. The

Dutch developments were the production of the Haring[27] Mistblower, which later became known as the Whirlwind Professor, and the production by Kiekens Dekker of their orchard mistblower. The Research Institute at Wageningen did much to encourage and foster these developments. Both machines were designed to apply 50 or less gallons of total spray per acre of mature orchard and therefore possessed fairly small capacity tanks. Both machines emitted a beam of air through an outlet which could be manually directed by a separate operator as the trailer unit was drawn through the orchard.

A variety of atomising heads were tried on these machines the simplest and perhaps the most interesting and efficient being the parasol nozzle that became a feature of the Whirlwind Professor. The parasol nozzle consists of a cup situated in the central axis of the air beam with the concave surface facing the source of air. The cup is shielded by a cone of approximately twice its area placed in the central axis of the airbeam on the upwind side. A column of liquid under pressure is forced into the centre of the concave surface of the cup. Due to the form of the cup and the forces involved the liquid changes direction and is thrown off the rim of the cup as a thin sheet. The liquid sheet continues to develop whilst it is protected from the airstream by the shield. Upon emerging from the protected area the sheet is shattered into droplets by the airstream. The size of droplets produced depends upon the quantity and pressure of the liquid fed, the viscosity, surface tension and density of the liquid and the characteristics of the airstream. With this type of nozzle it is impossible to achieve a very close droplet sprectrum but it has the advantage that no small apertures are required to achieve atomisation and fairly coarse suspensions can be sprayed easily.

First motorised knapsack

During the same period Keikens Dekker produced a prototype shoulder mounted mist blower. This machine consisted of a two stroke engine driving a fan unit mounted together with a spray tank upon a rucksack type harness. The unit was light enough to be carried by a man. Air from the fan was conducted through a flexible pipe to an outlet which could be held and directed in the operators hand. At the outlet the air stream was restricted by a venturi into which the spray liquid was fed.

These Dutch low volume machines rapidly gained acceptance in their own country as being able of providing protection of top fruit and other crops with 30 or less gallons per acre of spray liquid and are now widely used for the protection of tropical crops such as cocoa. Their success has led to prolific copying but the importance of designing nozzles which produce "mist" of small droplets has been conspicuously ignored in some machines.

1950—Andrews' rigid disc nozzle

During 1950[28], P. C. Andrews an engineer who had been working for a British aerial spraying company in Europe and Africa, became dissatisfied with conventional hydraulic boom sprayer attachments for aircraft. The rather crude droplet sprectrum together with the likelihood of nozzle blockages of the system seemed to Andrews to be undesirable characteristics if large areas were to be efficiently sprayed.

Andrews designed a rigid disc nozzle for attachment to an aircraft boom. The disc whose size could be varied, originally flat and later concave, was attached to a short stalk behind the boom. A column of spray under pressure was directed onto the centre of the disc where it changed direction to form a sheet on the edge of the disc. In still air this sheet would ultimately shatter into droplets. In the moving air provided by the foreward movement of the aircraft the larger droplets were subjected to some secondary air blast atomisation. Since atomisation by this rigid disc nozzle was not dependent upon pressure, large non-blocking liquid appertures and relatively low pump pressure could be employed. Varying disc size and output together with the physical characteristics of the spray liquid could provide variations in droplet size with Andrews' nozzle. When performing under optimum conditions the rigid disc atomiser is claimed to be capable of both a finer and more even droplet spectrum than can be obtained when using a conventional hydraulic boom.

It is difficult to imagine why this type of atomiser did not become more widely adopted especially since it appears ideal for handling the cheaper wettable formulations.

In Britain in 1951 J. Stapley of Plant Protection Ltd., using Bray jets attached to an Autoblast machine initiated low volume trials in orchards applying conventional chemicals in higher concentrations at 50 gallons per acre. The satisfactory results obtained by Stapley were, to some extent, responsible for the British Orchard Growers' move from applications at 200 to 300 gallons per acre to 30 to 50 gallons per acre.

Moore's experiments

At East Malling Research Station in England in 1947, M. H. Moore began his classic experiments in which he applied small volumes of various concentrations of Lime sulphur to fruit trees using a paint gun for the application. Lime sulphur being a liquid it was possible to vary the concentration of spray from 1% to 100%. In 1952 Moore[29] reported at length upon his findings in relation to the application of Lime sulphur at various concentrations and dosages in various droplet sizes.

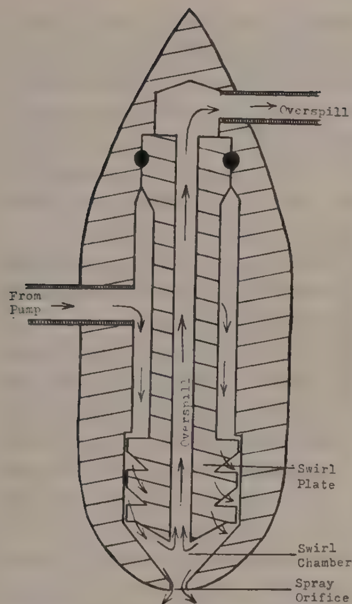
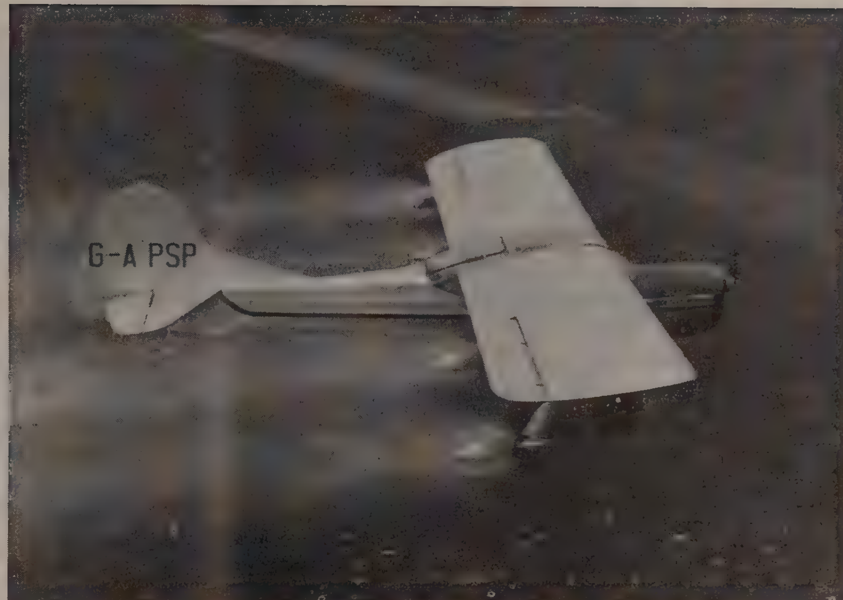


Diagram of the Drake & Fletcher Unimist nozzle.

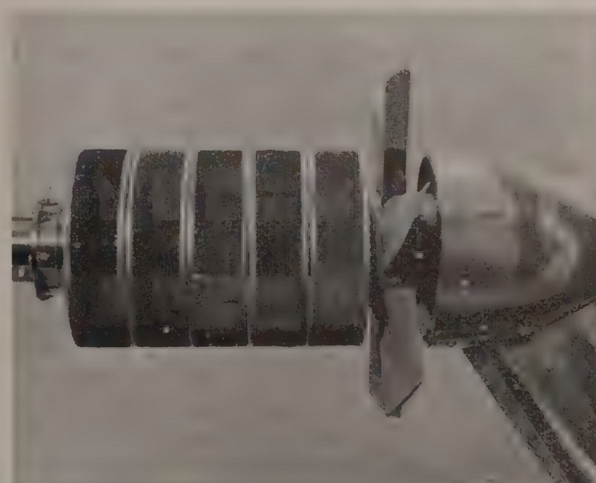


Four Britten-Norman Micronair A 1,000 rotary cage atomisers fitted to an Auster Workmaster. Photo Crop Culture (Aerial) Ltd.

This paper has already become a document of historic interest and served as a tremendous fillip to the protagonists of the concentrate idea. By 1952 Moore had done enough work to suggest with confidence that one of the worlds most important plant diseases (apple scab) could be controlled by applying lime sulphur at 100% concentration in ultra-low volumes (3-6 gallons per acre), provided that attention was paid to the fineness and evenness of the droplet spectrum. One interesting outcome of Moore's work was the fact that 100% lime sulphur applied at ultra-low volume with fine droplets was less likely to produce scorch than the same material applied high volume at 5% concentration. Even certain sulphur shy varieties of apples seemed to tolerate the concentrate treatment.

As the result of Moore's work the National Institute of Agricultural Engineering[30] produced in 1952 their first prototype sprayer to carry out extended field trials in collaboration with East Malling research station. Although this machine did not provide satisfactory atomisation, experience was gained which enabled a much more successful prototype concentrate sprayer to be built in 1953. This unit consisted of a fan and ducting with a moveable air outlet that could be directed by an operator. The atomising system consisted of a battery of high speed air jets set in the air outlet. The jets were operated by a seperate compressor. A four cylinder water cooled engine provided power for the fan and compressor. The unit was designed as a trailer to be tractor drawn.

This second N.I.A.E. prototype machine provided an excellent test bed for preliminary studies upon droplet placement etc.



The Micronair A 1,000 Rotary Cage Atomiser. Photo Crop Culture (Aerial) Ltd.

1952. The Iden 100%

The history of concentrate spraying is peopled with its share of lively personalities; most of them have been engineers, entomologists or plant pathologists. In 1952 a man of alarming candour and a fertile gallic imagination appeared on the scene. John Roberts[31] was probably the first professional fruit grower to design a true concentrate sprayer and also the first fruit grower to accept the validity of the concentrate idea. Familiar with the work of Moore at East Malling and conscious of a need to increase the speed and efficiency and decrease the cost of spray operations in the orchard John Roberts

built his first prototype machine. In order to achieve the atomisation essential for successful concentrate spraying Roberts adapted high speed air jets to his machine.

Roberts machine, which he called the 'Iden 100%' was the first fully automatic pure concentrate sprayer. The high speed air jets being set in an arc around the radial outlet of a high volume fan. Roberts first machine was powered by an independent engine but later it was refined by the substitution of a glass fibre spray tank, a p.t.o. drive and a provision for the attachment of a different set of nozzles, should wettable powders have to be sprayed. Roberts sprayed two experimental blocks in 1953 and by 1955 had gained sufficient confidence in his system to spray his entire fruit acreage with concentrate sprays.

Roberts machine was open to some criticism since the high speed air jets originally fitted were not ideal for handling wettable powders. Roberts argument was that his main job as a fruit grower was to apply fortnightly rounds of fungicide to control scab and Moore's work had shown that 100% lime sulphur, a liquid, would do this job. Roberts made his machines available commercially to other growers in 1956 and many of them are working successfully today in Britain and Overseas.

1954—The search for better nozzles

By 1954 it became clear that chemical manufacturers in Britain were prepared to recommend application rates of 30-50 gallons per acre of orchard as a practical proposition. On the other hand, it was appreciated that many growers would be reluctant to swing from 300 to 30 gallons per acre, and also that some chemicals might be less efficient at the lower volume rates. Additional to this, the variation of orchards, bush and standard on the same farm, demanded that it should be possible to regulate the output quickly.

The nozzles then available for low volumes had a number of limitations; these generally included small apertures liable to blockage and high rates of wear. Wear in a low volume nozzle is more important than in a high volume nozzle. Even a 10% increase in diameter of the nozzle orifice results in an output increase of almost 25% which with high concentrations can be serious. The use of nozzles or atomisers in other industries is far more extensive than is usually realised and so it was logical that some of the more unorthodox types should be considered. It was not, however, until atomisers used in aircraft engines were under review that any resemblence to the problem became apparent. Here the difficulty of obtaining a wide range of fuel flow had been encountered and a number of ingenious methods were used. With an aircraft engine, conditions are obviously totally different, the viscosity of the fuel is known, it is not abrasive nor corrosive, and finally, the layout is far too elaborate for agricultural purposes.

A prototype nozzle was produced by Drake & Fletcher Limited[32] of Maidstone which was approximately 5″ long x 1½″ diameter, it originally being considered that one nozzle only would be necessary. The results from this nozzle were generally disappointing, the droplet size was far too large, but at least it was proved that a large output range could be obtained and controlled without any of the elaborate equipment used on aircraft. As a result of this, nozzles of various sizes and apertures were subsequently produced and tested until finally one, which gave a satisfactory droplet size and output, was developed and became known as the Unimist nozzle. The Unimist nozzle, marketed in 1954, relies for its success upon a spill tube. The liquid is fed into the nozzle in a similar manner to any of the standard swirl nozzles, passes through a swirl plug and into a swirl or vortex chamber. The swirl plug, however, has an orifice at its centre leading to a tube which is bled out at the base of the nozzle. The diameter of the nozzle orifice is approximately ⅛″ and the size of the spill tube slightly greater. The output of the nozzle is adjusted by varying the amount of liquid allowed back down the spill tube and it can also be varied by altering the pressure of the liquid fed into the nozzle.

Liquid is fed into the nozzle, as the valve on the spill tube is opened, so the liquid in the swirl chamber is allowed to pass back down it. By the nature of any swirl nozzle a vortex is created in the chamber, the core of this vortex being filled with air. As the spill valve is opened so the air core increases in diameter and an ever thinner sheet of liquid escapes over the edge of the nozzle orifice. The velocity of the swirl is fully maintained, however, as the full output of the pump is still being fed into the nozzles. Thus the same rate of swirl or angular velocity is maintained and combined with an ever thinner sheet of liquid passing over the nozzle orifice ensures that droplet sizes get smaller as the output decreases; no alteration of the nozzle cap or orifice is ever made. In the initial tests it was found that, due to the exceptionally high rate of swirl achieved at all outputs, the internal conical head of the nozzle wore out in a very short time, so, in conjunction with Messrs. K. L. G., the hylumina cap was developed. Hylumina is a ceramic of the aluminium oxide group and for hardness is far superior to any of the available steels and neutral to all chemicals.

Byass[33] in 1956 hinted that it would be possible to produce a simple airblast nozzle that would, under the right conditions, be capable of producing droplets of the dimensions considered suitable for true concentrate applications and which, at the same time would be capable of atomising the larger volumes of liquid required for higher volume spraying. Together with his colleagues

at the National Institute of Agricultural Engineering, Byass had produced by 1958 a satisfactory prototype sprayer capable of concentrate or higher volume spraying.

SPINNING DISCS.

The Gypsy Moth (*Porthetria dispar*) control division of the U.S.D.A. used in 1944 an aircraft fitted with a spinning disc assembly. It was produced to handle sprays such as heavy suspensions or emulsions which had abrasive characteristics and which were in consequence providing a pump wear problem.

The disc atomisers[34] resembled in some respect the Hession discs described in part II. They differed from Hession's discs in that the feeding surface was slightly concave. The atomisers were directly driven by a 6″ windmill in flight achieved 2,500 r.p.m. Since discs do not require a high pressure feed to provide atomisation a gravity feed arrangement was incorporated thus obviating the necessity for a pump that could provide wear problems. DDT, lead arsenate and cryolite were all successfully sprayed with this equipment.

One reason why this equipment was not more widely adopted appears to have been the difficulty in maintaining an even liquid feed rate. This is surprising since it is possible to produce a perfectly adequate uniform gravity feed tank.

1949—The spinning disc re-examined

The British development of significance in 1949 was the commercial production of the first genuine concentrate sprayer capable of handling all types of spray chemical by E. J. Bals[35].

Having witnessed the arduous nature of the knapsack spraying operations to control blister blight on tea in Indonesia and Ceylon, Bals sought a method of atomisation which would enable the fungicide to be applied evenly in ultra low volumes of diluent liquid. He wanted droplets small enough to drift a controlled distance but larger than fog particles. Bals realised that conventional hydraulic nozzles would not provide a fine enough droplet spectrum to provide adequate cover with very low volumes and that the high speed air jet would not be satisfactory when handling coarse powders in suspension.

Fine spray on his windscreen thrown from the wheels of cars he was following on wet roads led him to re-examine the potentialities of the spinning disc. His studies led to the development of the first prototype Standard Micron Sprayer.

This machine embodied many revolutionary features. It consisted of a low horse power aircooled four stroke engine driving a paddle fan mounted directly on the engine shaft. The fan casing could be swivelled to alter the position of its outlet. The fan and engine unit were mounted upon the tank and the whole was mounted upon a turntable so that the outlet could be directed at will. The atomiser itself consisted of a cup mounted in the airflow axis at the outlet of the machine. In operation the cup was rotated rapidly about a fixed spindle driven directly by the airstream activitating a windmill attached to the rear of the cup. Spray liquid fed to the centre of the spinning cup was thrown off the rim as thin ligaments which broke down into droplets. The size of the resultant droplets depended upon the speed of rotation the diameter of the cup and the surface tension and specific gravity of the liquid. Within reasonable limits neither the viscosity of the liquid nor the rate of feed seemed to have a profound influence upon the droplet spectrum.

The advantages of the Micron atomiser lay in the evenness of droplet produced and the fineness of droplet that could be altered by changing the speed of rotation. Since aperture size played no part in atomisation large apertures could be used throughout and the likelihood of blockages in the liquid system was consequently reduced.

Once it became clear to Bals that he had developed a system of atomisation capable of providing intense cover with small volumes of liquid he could design machines specifically for concentrate spraying. With rates of application of ½ to 10 gallons per acre in mind he could reduce tank size and use the tank as an integral part of the chassis of his machine. Since the volumes to be applied were low he could afford to use low pressure, low output and consequently low power requirement centrifugal pumps to supply liquid to his atomising head.

The result was that Bals units were capable of a big work output whilst being much smaller and lighter than previous machines. In a sense his talent for design may have been of dis-service to him since, apart from the natural scepticism that ultra low volumes of spray would provide adequate control of pests and diseases, many people found it difficult to believe that such lightweight machines could do a heavyweight job.

Bals early attempts to solve the blister blight problem which had stimulated the production of his Micron sprayer met with little success. At the time only water based fungicides were available and small water based droplets tended to evaporate rapidly in hot climates. This meant that the swath that could be adequately treated under tropical conditions was strictly limited. Tea is mostly grown in large blocks and the limited swath was inadequate to allow treatment from the paths between the blocks. The answer to the problem was either a very lightweight machine that could be carried through the crop table or a chemical less susceptible to evaporation. Neither the machine or the chemical arrived until much later. Bals initial work was not wasted and his system began to be tested as a possible solution to other problems.

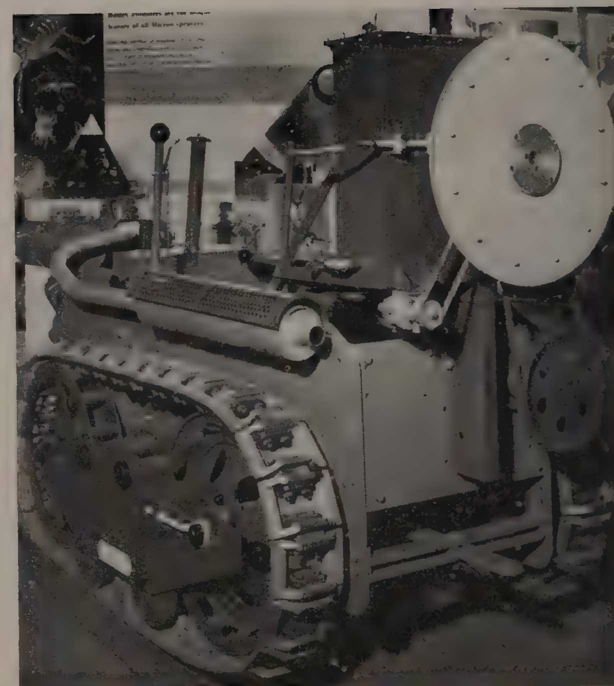
1953—Oil based pesticides renew activity in concentrate spraying

1953 will probably be considered to be the most significant year in the acceptance of the concentrate spraying notion. E. J. Bals since his disappointments, in 1949/1950[35], with the limited value of water based fungicides applied as small droplets in warm climates, had done everything possible to foster the application of pesticides in oil. The results obtained by Joyce[36] during 1952 using the Standard Micron sprayer to apply very low gallonages of oil based DDT to control capsid, jassid and flea beetle upon cotton in the Sudan and the successes of Vanderplank[37] in controlling the coreid bug *Theraptus* attacking tall coconut palms in Zanzibar using the same machine and oil based DDT suggested that oil based sprays could be applied to plants under certain conditions without causing obvious damage.

During that year Bals, who had become conscious of certain short-comings in his rotating cup atomiser carried out a series of experiments which resulted in the production of the milled disc. The disadvantage of the plain lipped cup was that after an optimum feed had been reached, slip took place and the full circumferential force developed by the rim of the atomiser could not be imparted to the spray liquid. The milled disc went some way towards overcoming this problem and proved on a diameter basis to be much more efficient than the simple cup. Initially the increased efficiency was used to diminish atomiser diameter whilst maintaining performance. The smaller diameter atomiser could be built into the first shoulder mounted concentrate sprayer—the 'Mini-Micron' sprayer—which Bals produced in 1953.

Jean Cuille[38] of I.F.A.C., Paris, was at that time investigating the possibilities of diminishing the efforts required in order to protect bananas from sigatoka disease. He was attracted by the reduction in volume which appeared to be offered by the concentrate method and met Bals. During the discussion which took place Bals lamented the lack of a suitably formulated oil based copper funicide.

Subsequently Cuille took a Mini-Micron machine to the French West Indies and in conjunction with Guyot carried out the first concentrate experiments with an oil based copper fungicide made in the field. The results were so successful that Cuillé upon his return to France was able to encourage Usines Schloesing Freres in Marsilles to produce a copper in oil formulation especially designed for concentrate application. Shortly afterwards a British firm[39], the Standardised Disinfectants Co. Ltd., produced an oil based copper formulation. These two oil based copper fungicides heralded an era of special concentrate formulations which has been responsible for much wider acceptance of the concentrate technique.



The Micron Vineyard sprayer mounted on a Ransomes, Sims & Jefferies tractor. Photo Micron Sprayers Ltd.

News of the French leaf spot work spread rapidly and today its impact can be felt in nearly all the serious banana growing countries.

The rotary cage appears

During 1954 Bals[25] carried out a number of experiments with rotary atomisers. He found that a supported cylinder of nylon velvet rotating quickly and fed with solutions could produce extremely fine and even droplets. It appeared that each small thread of nylon was acting as an issuing point for the formation of ligaments of spray which later broke down into droplets. Such an atomiser would not be useful in practice since only true solutions were capable of passing through the nylon velvet. As a compromise Bals manufactured an atomiser which consisted of a supported cylinder of metal gauze. This cylinder provided a large number of issuing points for ligament formation whilst allowing powders in suspension to pass. This type of atomiser became known as the 'Micron cage atomiser' and with only minor refinement it is still being manufactured and used today.

During the early part of 1954 Britten-Norman Ltd.[40], who were currently manufacturing Agricultural Aviation Equipment, carried out a survey of existing spraying systems in order to decide which system offered the most promise for aerial development. The versatility of Bals' rotary cage atomiser appealed to them since

the droplet spectrum could be subjected to a controlled variation and it was capable of handling solids in suspension without blockage. The Bals' rotary cage was developed by Britten-Norman Ltd. to make it suitable for aerial work. Among other modifications the surface area of the cage had to be greately increased to cope with higher rates of output. The Britten-Norman development work resulted in the production of the Micronair A.100 rotary atomiser. For spraying operations two of these atomisers were initially attached to the upper surface of the lower wing of Tiger Moth aircraft. The A.100 atomisers were driven by a V belt drive from a windmill. Varying the pitch of the windmill blade varied the revolutions of the atomisers and consequently the droplet size.

This equipment soon established its value when used for control of jassid and thrips attacking cotton in the Sudan and has subsequently been instrumental in hastening the acceptance of aerial spraying in a wide range of crops throughout the world.

By 1958 Britten-Norman Ltd. by increasing the diameter and length of their Micronair cage atomiser had managed to obviate the need for a geared drive and were able to attach the driving windmill direct to the cage atomiser. The new atomiser was marketed in that year as the 'Micronair A 1,000 Atomiser'.

The existence of oil based formulations allowed Edward[41] in 1956 to demonstrate that blister blight could be controlled on tea with less than one gallon of total spray per acre as had been predicted by Bals in 1949.

1959—The airstream dispensed with

Latterly there has been a good deal of speculation as to the exact role played by the airstream generated by high or low volume sprayers. In the past there was a tendency to believe that the bulk of the spray droplets were carried to their destination in the airstream generated by the sprayer and that the strength and direction of the air currents prevailing over the treated area influenced the beam of air from the machine. However since leeward surfaces in practice seem to receive such scant doses of chemical it seems unlikely that this notion is valid. Some people today will suggest that a very high proportion of the volume of spray emitted arrives at its final destination under the influence of local air currents whilst admitting that the point of arrival will be influenced by the point of departure which in turn can be influenced by the air characteristic of the sprayer.

The above considerations led Bals[35] in 1959 to experiment with a concentrate sprayer that would provide fine even droplets in the absence of an airstream. The prototype he built and the results of deposit tests led to the commercial production of the Micron Vineyard Sprayer and the Micron Tomato sprayer. Both these machines are identical in principle consisting of a large diameter rotary atomiser turning relatively slowly (2,500 r.p.m.). Spray fed to the centre of the atomiser is thrown off the rim as fine drops. The centrifugal force imparted by the disc hurls the droplets from the atomiser in a wide arc which forms a cloud behind the machine. In hedge crops such as vines, tomatoes and cordon fruit some of the droplets impact upon foliage under the centrifugal force from the atomiser, others drift onto the foliage under the influence of the local aircurrents.

Whether this type of machine can be used to provide adequate spray deposits upon tall tree crops is doubtful but must form a subject for future experiment.

Conclusion

An attempt has been made above to trace the history of the concentrate spraying idea. Readers informed about certain aspects of the field will have noticed that there has been no mention of many people or organisations that have helped in popularising the idea either by manufacturing or by conducting early experiments. The reason for these omissions is that adequate acknowledgment would be impossible in an article of review length. It is hoped that all the important innovations have been mentioned and that the attributions are correct.

REFERENCES

22 PERCH, L. C. The development of Air-assisted spraying machinery. *Spraying techniques in Agriculture.* London.
23 BRANN, J. L. (1956) *Ann. Rev. Ent.* **1.**
24 MARSHALL, J. (1951) *Ento. Soc. British Columbia Proc.* **48,** and *Private Comm.*
25 TEMPLEMAN, W. G. *Journal of Min. of Agr.* (U.K.) January 1949.
26 LANE, F. W. J. *Private Comm.* Plant Protection Ltd., Fernhurst, Surrey.
27 HARING W. *Private Comm.*
28 ANDREWS, P. C. *Private Comm.*
29 MOORE, M. H. *Rep. East Malling Res. Stn. for 1952.* 132/5 (1953)
30 COURSHEE, R. J. DAYNES, F. K., BYASS, J. B. A tree spraying machine. *N.I.A.E. Report No. 36* (1944)
31 ROBERTS, J. *Private Comm.* Iden Stackers & Graders Ltd. Iden, Sussex.
32 FLETCHER, G., *Private Comm.* Drake & Fletcher & Co. Ltd., Maidstone.
33 BYASS, J. B. Low volume spraying theory and experiment. *Proc Murphy Low volume spraying Conference. 1956.* The Murphy Chemical Co. Ltd., Wheathamsted.
34 YEOMANS, A. H. *U.S.D.A., E.C.2.* (1948).
35 BALS, E. J. *Private Comm.* Micron Sprayers Ltd., Birmingham
36 JOYCE, R. V. *Private Comm. & Sudan Gezeira Board.* Res Rep 1952.
37 VANDERPLANK, F. L. (1954) Field experience with spray nozzles in the tropics. *World Crops,* **6** (12).
38 CUILLE, J. & GUYOT, H., *Fruits,* **9,** (7), 1954.
39 HOPE, N. *Private Comm.* S.D.C. Pesticides Ltd., London.
40 BRITTEN, F. R. J. & NORMAN, N. D. *Private Comm.* Britten Norman Ltd. I.O.W.
41 EDWARD, I. D. *Private Comm.* Pierce Leslie & Co. Ltd., London.

Much of the material which forms the substance of these three articles will be incorporated in the second edition of Crop Protection *to be published shortly by Leonard Hill (Books) Ltd.*

NEWS AND NOTES

1961 B.W.P.A Convention

The 1961 British Wood Preserving Association's Convention will be held at Cambridge University from Tuesday, July 11th to Friday, July 14th. Delegates will assemble for dinner in college on the evening of Tuesday, July 11th and the first official session will be held in the lecture rooms of the School of Physical Chemistry, Lensfield Road at 9-30 a.m. on Wednesday, July 12th The official meetings will continue throughout the days of Wednesday and Thursday, July 12th and 13th. The Convention will end after breakfast on the morning of Friday, July 14th. On the evening of Tuesday, July 11th an informal reception for all delegates will be held in the Hall of Pembroke College from 9-0 p.m. to 10-15 p.m. On the evening of Thursday, July 13th the official Reception and Dinner will be held at the Dorothy Restaurant at 7-30 p.m. for 8-0 p.m.

Accommodation for male delegates has been reserved in the Clare, Pembroke and Sidney Sussex College and *applications to attend the Convention should be made no later than June 23rd, 1961.* Ladies wishing to attend should make early application to the hotel at which they intend to stay, as it is not possible for them to be given accommodation in college.

The papers to be presented include.

(1) X-Ray Spectographic Analysis—A New Technique for Wood Preservation, by Dr. D. S. Belford, Hickson's Timber Impregnation (G.B.) Ltd.

(2) The Use of Contact Insecticides, by Miss J. M. Taylor, Forest Products Research Laboratory.

(3) The Use of X-Rays in Testing Wood Preserving Insecticides, by Monsieur C. Jaquiot, Centre Technique du Bois, Paris.

(4) Treatment of Wooden Sleepers and Other Railway Timbers in Germany, by Dr. Georg Schulz, Bundesbahn-Zentralamt, Germany

(5) Preservation Treatment of Eucalypt Poles and Cross Arms in Australia, by Mr. W. G. Keating, Postmaster General's Dept. Australia.

(6) *In situ* Treatment of Dry Rot, by Mr. A. A. Tyrer, Woodworm and Dry Rot Control Ltd.

(7) Permeability of Floated and Unfloated Timber, by Mr. Hans Holmgren, Forest Research Institute, Sweden.

Further details and application are obtainable from:- British Wood Preserving Association, 6, Southampton Place, London, W.C.1.

Insect Pathology and Biological Control

The book *Transactions of the 1st International Conference on Insect Pathology and Biological Control* which was reviewed in "*Pest Technology*", July 1960, is now available in the United Kingdom through:- Collet's Holdings Ltd., 44-45, Museum Street, London, W.C.1.

Previously the book had to be ordered from the Czechoslovak Academy of Sciences, Prague. The price is 50/-.

Readers may recall that this publication is a report of the conference which was held in Prague in 1958. The papers are published in the language in which they were read. Those in Russian or similar tongue have a summary in a western language (i.e. French, English or German) and vice versa. The publication should be especially useful for workers interested in the biological control of insects by the use of micro-organisms.

Mechanisation May Increase Pyrethrum Production

The Pyrethrum Board of Kenya is studying trials of a new mechanical transplanter which could revolutionise the cultivation of pyrethrum flowers. At the moment pyrethrum "splits" formed by subdividing mature plants, are planted by hand—a long and laborious task. In recent trials, using the two-row mechanical transplanter, 1.2 acres were planted in three hours. If the transplanter proves practicable on a large scale, it should help the pyrethrum growers to increase production to meet the rising world demand for Kenyan pyrethrum insecticide. The trials are being conducted by Alse Ltd. of South Kinangop.

Comments from the U.S.

"The development of more effective pesticides is one of the reasons why it takes only twelve per cent. of our population to produce food, clothing and shelter for the remaining eighty-eight per cent. . . . who are free to engage in activities to provide the highest standard of living for all of us." — *Congressman J. L. Whitten.*

"Except for the antibiotics, there are probably no materials that protect the world's people against more diseases than do the chloronated hydrocarbon insecticides." — *Dr. Henry van Zile Hyde. Division of International Health Public Health Service.*

"Impartial scientific and public bodies have found that pesticides are necessary to protect the nation's food supply and public health and can be wisely and safely used.

"The factual evidence is overwhelmingly on our side and we should welcome any opportunity to tell our story. When and where we've had the chance and done so, we have never regretted it." — *Jackson V. Vernon, President of the N.A.C.A.*

The above are quotations from the National Agricultural Chemicals Association (of America) 27th Annual Meeting.

Timber Underground

An advisory panel has been set up by the Timber Development Association in London to guide research into the use and preservation of timber in mines. A development programme is being studied in collaboration with the British Wood Preserving Association, the Forestry Commission and the Forest Products Research Laboratory.

Technical Bulletins and Leaflets

Embafume :— A well produced 28 page technical information bulletin describing the usages of the "Embafume" brand of methyl bromide which conforms to B.S. 2710: 56. The pest species controlled are listed and most aspects of fumigation, such as fumigation of barges, ships, flour mills, seed beds, seed and grain stores, silos, etc., and vacuum fumigation and fumigation under gas proofed sheets, are covered. There are also sections on the equipment required and the fumigation schedules to be followed. Hazards of the use of methyl bromide are also discussed. Available from May & Baker, Ltd., Dagenham, Essex, England.

NEW PUBLICATIONS

Report Of The 7th Commonwealth Entomological Conference. July 1960

Published by the Commonwealth Institute of Entomology, London. *Price* 50/-

Following an official, eleven page report of the 7th Commonwealth Entomological Conference, which was held in July 1960, this 400 page publication is divided into five sections. Appendices I and II are the memoranda of, respectively, the "Work of the Commonwealth Institute of Entomology from April 1954 to March 1960" and the "Organisation and Work of the Commonwealth Institute of Biological Control", with appendix III being devoted to the "Proceedings of Committees". The remaining 365 pages are divided almost equally between the "Proceedings of the Open Meetings" and "Reviews of the work in Economic Entomology in the Commonwealth from 1954-1959".

The Proceedings of the Open Meetings, which for many will be the most meaty and informative part of the book covers fourteen different subjects and includes thirty-one papers, with discussions. Examples of the subjects discussed are:—recent crop protection chemicals; pesticide hazards; stored products pests and their control; biological control; timber pests and termites; control of insects with viruses; tsetse flies and trypanosomiasis; locusts; plant viruses and vectors, and others. To review each paper scientifically critically would require a number of authoritative reviewers equal to the number of authors but papers which particularly caught our attention included, "Recent Developments in Insecticides for Crop Protection," by Dr. J. T. Martin, "Hazards from Using Pesticides" by Dr. J. M. Barnes, Tecwyn Jones' paper on timber boring beetles, and Dr. K. M. Smith's account of the use of viruses for the control of insects. Papers by Dr. P. T. Haskell and Dr. R. C. Rainey on Research on locusts and their control and by Mr. I. Ford and Dr. K. S. Hocking in the session dealing with research into the control of tsetse flies and trypanosomiasis are to be recommended.

Record Of The 1960 Annual Convention Of The British Wood Preserving Association

Published by the British Wood Preserving Association, London. *Price* 12/6

The record of the British Wood Preserving Association's annual convention has become established as a reference book in the Wood Preserving Industry and possibly also with the surveying and architectural professions.

The papers presented in this publication follow the usual high standard of previous years. For the pest technologist and entomologist the paper "The Economic Ecology of Some Tree Boring Beetles of

Tropical Africa" by Tecwyn Jones, is to be recommended as it deals largely with the activities of two recently discovered pests of living trees, namely *Oemida gahani*, and the unnamed borer of *Isoberlinia scheffleri*. Because of their recent discovery and cryptic habits the life histories of these pests are little understood so that this account should be most valuable.

"An Introduction to the Study of the British Lyctidae" by N. E. Hickin deserves to become a standard reference to the wood preserving industry as a key to the identification of these insects. Although mainly restricted to factual descriptions of the biology of Lyctid beetles the author indicates the dangers of generalising on the life history and ecology of these insects.

The other papers are "The development and marketing of pressure treated wood in the U.S.", "Fire retardent surface coatings in principle and practice", "Practical applications of pressure treated flame proofed timber", and a "Progress report on the British Wood Preserving Association". There is also a summary of the Convention papers by Dr. D. McNeil, and discussions on all papers. As the B.W.P.A. take the trouble to circulate pre-prints of each paper *before* the convention, thus allowing adequate time for comment at each session, the discussions form an important part of the record and in the case of the papers by Dr. Hickin and Mr. Jones they are just as long.

Herbicides and the Soil

Edited by E. K. Woodford and G. R. Sagar.

Published by Blackwell Scientific Publications, Oxford. Price 17/6

The contents of this publication are composed of papers (and ensuing discussions) read before a symposium of the same title organised by the British Weed Control Council and held at the Clarendon Laboratories, Oxford.

The aspects of the fate of herbicides in the soil which are discussed are:—

"Microbiological breakdown of herbicides in soils" by L. J. Audus, Bedford College, London University.

"The effects of herbicides on soil micro-organisms" by Wm. W. Fletcher, West of Scotland Agricultural College.

"Physico-chemical aspects of the availability of herbicides in the soil". by G. S. Hartley, Chesterford Park Research Station.

"The Persistance of some important herbicides in the soil" by W. Van der Zweep, Wagenigen, Netherlands.

As one would expect from such notable authorities the papers are of high standard and contain much information not previously published, particularly the papers by L. J. Audus and Wm. W. Fletcher. Although the papers summarise the main part of present knowledge it appears that there is still much to be discovered as to the fate of herbicides in the soil and that a lot of research into the subject is required especially with regard to the long term effects of repeated application of herbicides. For example, although it is evident that the majority of herbicides do not reduce the total number of micro-organisms in the soil it is indicated that the relative numbers of the different species are altered and whether or not this "re organisation" will have any effect on soil fertility will only be resolved after a few more years of experiment and experience.

It is stated that "it is hoped that succeeding meetings (of the British Weed Control Council) will be reported in companion volumes", a sentiment with which we concur. Perhaps in subsequent volumes something can be done to lower the price for despite the highly informative nature of the contents the price of 17/6 for this 88 page, soft backed publication appears to be high in comparison to the equal cost of the 300 page, hard backed edition of the "Weed Control Handbook" which was also issued by the British Weed Control Council.

Horticultural Pests: Detection and Control. 3rd Edition.

by G. Fox Wilson, Revised by P. Becker.

Published by Crosby Lockwood, London. Price 25/-

The first edition of G. Fox Wilson's book under the title *Detection and Control of Garden Pests* was published in 1947 and at the time was regarded as a "really authoritative book on the detection of garden pests by the symptoms of plant injury" and an "indispensable work of reference". However, the subsequent rapid development of chemicals for the control of pests has outmoded some of the original control methods and the difficult and extensive task of revising the book and bringing it up to date became the lot of Dr. P. Becker who is also Mr. Wilson's successor to the post of Entomologist to the Royal Horticultural Society.

Dr. Becker has carried out this task in a most excellent and efficient manner and it would be unfair criticism to stress that there are some pesticides e.g. "Sevin" and "Gusathion" now in use which are not mentioned and that the Crop Protection Products Approval Scheme has been superseded by the similar Agricultural Chemicals Approval Scheme. The fact is that by the time any book dealing with pest control is in circulation, new information can be added. However, this does not imply that the methods given are out of date but reminds us that there may be, in one or two cases, newer and alternative materials.

In addition to methods of control Dr. Becker has also taken the opportunity of bringing the nomenclature up to date and to include a few new pests and to give further mention to others which have become more important.

Like the original editions the third edition is concerned mainly with the recognition of the many symptoms of pest damage and, with minor alterations, the original layout in which the book is divided into chapters corresponding to the main parts of plants i.e. Bulbs, Corms and Tubers; Roots; Stems and Shoots, etc. is retained. The signs of attack which may be found on a particular part of the plant are described under various sections.